하이퍼스페이스 학습 환경에서의 인지 형태와 네비게이션의 교육 효과에 관한 연구

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요 약

본 논문에서는 최소한의 구조성을 갖는 하이퍼스페이스 학습 환경에서의 수업 진행에 있어서 두가지 개별적인 차이에 관하여 연구하였다. "펄 하버"라는 하이퍼 스택의 사용에 있어서 GEFT(Group Embeded Figure Test)를 통해 보면, 장 종속적인(Field Dependent) 사용자는 장 독립적인(Field Independent) 사용자보다 더욱 자주 지침서를 사용하였으며, 연구후 FI 사용자가 궁극적으로는 더욱 높은 시험 결과를 보여 주었다. 또한, FD 사용자가 일정한 형식의 진행 과정을 보여 주지 않은 데 반해, FI 사용자는 일정한 형태의 학습 진행 과정을 나타내었으며, 영상 사고가 높은 학습자가 하이퍼스페이스 학습환경에서 더욱 큰 교육 효과를 얻게되는 것으로 나타났다.

Effects of Cognitive Styles and Navigation in HyperSpace Learning Environment

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ABSTRACT

This study examined individual differences in navigating in hyperspace learning environment where a minimum structure is provided. Using a hypercard stack called "Pearl Harbor", Field Dependent people used guidance more often than those in Field Indepedent; FI achieved scored higher at the end of the study; and FI people had some type of pattern showing from them audit trail when FD people did not show any trail of patterns. Also people with higher visual thinking scores achieved higher scores in hyperspace environment.

1. Introduction

One of the newest kid on the block for the educational community in computer based training is hypermedia. The terms such as hypermedia and hypertext are no longer unfamiliar terms and its application offers significant improvement in facilitating learning and teaching. Advocates of these relatively new and available hypermedia systems claim that it models human associative memory and can serve as powerful cognitive amplifiers [11], and cognitive enhancers [5]. The potential of using such technology can be a powerful tool in educational and training environment.

Since hypermedia environments can be unstructured and let the learner develop and use their own structures in sequencing their own learning, it is necessary to study

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how individuals differ in their search for information. It is thought that field independent individuals tend to structure information and field dependent individuals tend to be less analytical. Therefore, information access patterns, learning, and retention, theoretically, should be different for these two types of users since they focus on different aspects of the information presented [15].

The non-linear access of information in presentation is one of the many attractive features since it allows the user to control not only the speed of the information presentation, but also the sequences, depth, and the type of information to be seen. However, many researchers have indicated that learners have a tendency to become lost or disoriented while using hypertext or hypermedia lessons and materials. This very powerful feature could also interfere with learning process due to disorientation for some learners. There is a need for more studies addressing the individual differences in learning hypermedia environment. Some learners have more difficult time learning or feel overwhelmed by the amount of information and the options to choose what they think they need to cover to complete the task [5, 9, 11, 14]

2. Literature Review

The information processing theory that accelerated cognitive theory development emerged after the World War II in 1940s. According to [1] this theory describes the learner as all active participant, interpreter and manipulator of environmental stimuli. It focuses the learners organization of thinking, ones strategies for problem solving, the process of learning, and the role of meaning in learning. Hypermedia seems to support the idea of cognitive theory with its unique characteristics in ideal format to present information to learners with different needs.

[5] defined the term hypermedia as framework for non-linear representation of symbols as an external associational memory where the technology provides assistance in organizing and accessing information. And these mixed media forms are controlled by hypertext [9]. This hypermedia environment requires the learner or the user to interact and explore the information by developing their own path knowledge structure. By the nature of this knowledge structure, the learners are encouraged to produce knowledge that could be transferred to other situations.

The nature of hypertext is defined in a variety of ways. Jonassen describes it as a node-link systems in a semantic structure that can map fairly directly the structure of knowledge it is presenting. It is an active cross-reference of database to allow the learner jump and select as desired, and computer-based medium for thinking and communication by [4]. It is usually noted as a various text information linked by related ideas allowing the learners to select and move around as they see the need.

2.1 Navigation in hypermedia

The learners browse an idea by using the linking mechanism of the hypertext elements [12] to find information that is individually meaningful and to acquire individualstic knowledge.

[11] pointed to the learner control issue as one of many challenges and problems facing instructional designers and educators in such systems. The rich, non-linear learning environment in hypermedia carries a risk of potential intellectual indigestion, loss of goal-directness, and cognitive entropy [6]. [14] also suggested possible reasons for this type of disorientation as that (1) the student usually does not have sufficient knowledge about the content to be learned, and therefore cannot make appropriate decisions in the selection of learning content and strategies, (2) the student may not have the metacognitive ability to accurately assess and predict his or her own learning process, and (3) the student may not have appropriate cognitive strategies for applying his or her experience and knowledge in the learning process.

Especially for those new to the system, disorie-

ntation is a problem even in relatively simple networks. [3] reported that even if the learners did not get lost, those with spatial visualizational ability seemed to retrieve information faster and turn to the top level less often. According to [11] the problem of disorientation can be overcome in instructional hypermedia once the users gain experience with the environment and by the instructional designers organization of the material. However, as information in hypermedia and its organization of the networks become larger, users tend to experience greater navigational problems and more anxiety.

Learners may feel overwhelmed by the amount of information and the options to choose what they think they need to cover to complete the task. The term cognitive overhead by [4] described as the degree of complexity in a non-linear environment with the number of choices given to students, task scheduling, tracking, and navigating.

[14] cites the work of Tennyson and suggests the use of advisory information to help learners make better decisions in CAI. Having a simple map or spatial advisory information may be inadequate for large networks since it may not help them to navigate in conceptual space. If the learners goal in this environment is to become oriented conceptually, then they should be provided with conceptual orientation [16].

As learners browse to find relevant information, these navigational paths through the contents can be automatically traced in the computer. The audit trail is a collection of the various responses or choices generated by the learner while he/she was going through the interactive or hypermediated instruction.

2.2 Cognitive Strategies and Learning Styles

[8] cites learning strategies from [2]. They presented four general categories of individual differences that relate to learning strategies: the abilities, cognitive style, prior knowledge, and affect/motivation. Especially, the cognitive learning style of field independent/dependent [18] has been researched most often because they can be related to learning behavior [16]. These cognitive styles were measured to examine the correlation between the ability to (1) attend to relevant information, (2) engage in self-directed learning, and (3) process new information to evaluate and synthesize in order to form conclusions based on the information provided.

It is reported that field dependent individuals were more successful with and less frustrated by extracting global information from the details presented. The field dependent people tried to look for a big picture through detailed information. However, field independent individuals may be overwhelmed by the details presented in a hypermedia information system. They are usually more focused with specific details.

2.3 Visual and Verbal Problem Solving

Accoriding to [3] there have been very few studies that showed a systematic relation between spatial visualization ability and efficiency of locating information in a hypertext-based system. They define visualization as the ability to perceive and manipulate spatial patterns. Visual skills are considered to reduce disorientation and lead to more efficient navigation and information retrieval in a hierarchical hypertext system. Based on previous work, it was expected that people with stronger visualization skills would be more efficient at finding information.

2.4 Metacognition

Metacognition is an executive engine of cognition [13]. It enables one to be aware of the processes of ones learning and monitors planning. This ability monitors the selection and application of solution processes as well as ongoing feelings about self and task. This ability is directly related to successful learning and may be of paramount importance when learning, especially, in a hypermedia environment.

Among the metacognition abilities studies, motivation is a particularly interesting issue since the

hypermedia environment has the potential to either satisfy users information needs by linking their information-seeking efforts to specific learning tasks [15] or totally unmotivated thus causing disorientation.

[17] cited the need and importance for more study about how to capitalize on metacognitive processes of setting goals, planning, and recognizing problems in using electronic text. [15] also agree that in a hypermedia environment, the activity is highly personal, interactive, independent, individualized and involves self-directed tasks. It is considered vital to know the relationship between learners understanding and interpretation of the tasks and the way an electronic system supports that interpretation.

3. Issues

A review of the literature reveals interactive instructional systems to be an effective and powerful interactive tool for learning and teaching to satisfy different range of learning needs. Each learner brings different prior experiences and capacities in selecting information to satify their needs. Therefore, it is only natural that learners prefer to access, interact, manipulate, and transfer knowledge differently. Their individual differences in cognitive styles and strategies will be unique. Hypermedia Assisted Instruction (HAI) is capable of providing an individualized, and nonlinear method of instruction that links associative and related information to engage the individual learner in meaningful learning in multimedia format.

The hypermedia format is likely to encourage thinking, speculation, and personal judgments on the part of the learner. Thus, these mental efforts require the learner to apply their higher order thinking skills to absorb the systems layers of material. At the same time, these mental efforts could also contribute to the fact that the learner may have a difficult time gaining a compure of material.

Researchers have indicated that learners have a tendency to become lost or disoriented while using hypertext or hypermedia lessons and materials [5, 9]. However, [7] states that if too much structure is provided in hypermedia environments, the idea of non-structure for exploratory and discovery of non-linear environment becomes negated. Learner control can be confusing for some because it increases the decision-making load on the learners. [11] states that the learners cognitive resources may be diverted and decrease learning from content and relationships as learners attend to navigational decision-making; moreover, the cost of freedom given to learners could cause possible disorientation [4].

4. Statement of Problem

[9] addressed the need for more researches in hypertext environments where no structure is provided, where the users must develop their own mental models or structures to retireve relevant information. Therefore, one of the most obvious problems in learning within hypermedia environment is an issue of navigation. We have defined this as a HyperSpace environment. The concept of HyperSpace can be defined as that it has few hyperlinks to connect different concepts, people and ideas to group them, and no clear structure is used to present the information. This environment invites the learners to use and develop their own knowledge structure to find the links to synthesize information rather than using or imitating the structure provided by the instructional designer.

The researcher suspected that navigational problems in hypermedia could be related to learner characteristics, mental modeling, and higher order thinking skills. In particular, the researchers suspected of different type of learners. There may be a type of learners who may become lost and lack the ability to effectively locate and organize information for problem solving. Such disorientation causes the user to get lost in HyperSpace due to the quantity of information available, the ability to be able to jump

from one topic to another and thus user forgets where he/she is in the material. Thus, these navigational problems lead to ask following questions ;How will learners navigate in an unstructured and unaided hypermedia based learning environment? How and what learner characteristics could be used to predict different uses and possible paths the learner seeks to explore to learn and to transfer the knowledge? How and what kind of guidance would be appropriate to users in hypertexts? The fundamental hypothesis for this study was that the individual differences in their learning styles and strategies might influence their pattern or paths to seek information in non-structured hyperspaced environment.

5. Research Design

5.1 Study Population

The students in an introductory computer education course at a midwestern university were invited to participate in this study. The 29 participants in the experiment received extra credit toward their grade. About 95% of the student population were female ranging from freshman to graduate students. The average computer experience and their prior knowledge of the surprise attack on Pearl Harbor was rated on self-report likert scales ranging from 1 (low) to 5 (high). Due to lack of experience with computer and / or with hypermedia resulted five participants accidental termination of the experimental session causing a loss of data (which means interrupted the audit trail). Therefore, only 24 completed data were used for the study.

5.2 Material

The investigators constructed hyperspace based Hypermedia instruction on the surprise attack on Pearl Harbor on December 7, 1941(Fig 1). It contains hyperlinked information charts, documents, sound, and still images (graphics and photograph), and about the attack itself including when, how and the extent of losses. The learner is posed a problem, in a MISSION menubar item, to determine why the Pearl Harbor attack was such a surprise for the United States. The HyperCard stack included a path tracking mechanism called audit trail that recorded the type of information chosen, sequential (linear) path, the length of time spent on each card and the stack chosen by the participant.

5.3 Procedures

Before the actual experiment, a pilot study was conducted and at the beginning of the study the participants were informed of the topic Pearl Harbor, the MISSION item in the menubar had two questions they would have to answer at the end of the session, various types of buttons available for more information, and how to use scrolling fields in the CONCLUSIONS section for typing in their answer.

The students were also instructed to cover the materials as they would normally learn new materials, search for answers to the questions in the MISSION menubar item. When they felt they had enough information to answer the MISSION questions, they were to click the DONE button to write their conclusions.

5.4 Data Collection

The data collected for analysis included the automatically recorded information acquisition path through HyperSpace, depth of processing (amount of time devoted to information acquisition), the total time spent on the problem solving activity, the quality of the solution in cognitive complexity level, and the subjects written conclusion. Also demographic information and subjective student data were gathered through the exit questionnaire.

The students in the study were assessed using the GEFT (for Field Dependent/Independent), Visual Thinking for Verbal Problems Test (VTVP), and the Lindner and Harris Self-Regulated Learning Inventory [10]. The GEFT used to assess the subjects learning styles of their Field Dependent/Independent, and

VTVP was to assess their visualization ability of verbal problem sets. The Self-Regulated Learning Inventory was used to assess the metacognitive abilities.

The students response to the conclusion section was evaluated for their recall ability of facts and cognitive complexity using the Levels of Cognitive Complexity [13]. The Levels of Cognitive Complexity scale measured the students ability to assemble and analyze information in HyperSpace where very little structure is provided. The recall ability was evaluated with an information check list provided by the content expert who developed the hypermedia stack.

The audit trail of the learners navigational paths recorded card selections, menubar selections and their time in seconds. It also had *, **, ***, or none to indicate relevance of the information on the card to the MISSION (*** was considered very relevant). This particular mechanism provided vital information to examine depth of processing and relevant information searching strategies.

The total collection of data included the learning styles inventory, actual navigational path data, demographic information sheets, and an exit questionnaire. The exit questionnaire was used to collect the students own assessment of their searching strategies, reasons for their selected paths and general opinion of learning from an unstructured instructional environment.

To analyze the statistical data in the study, STATVIEW +SE was used with the Macintosh computer. The correlation coefficient was used to examine relationship between quality of subject conclusions and the various assessment variables.

6. Results And Discussion

6.1 Statistical Findings

Some significant correlation between the learning styles and other variables were revealed in this study from the audit trail data and the students conclusion. A correlational analysis showed a strong positive correlation (4=.437, p,.05) between Visual Thinking for Verbal Problems (VTVP) and correctness of conclusions. A person who is good at visual problem solving generally produced a higher quality conclusion in this HyperSpace environment. The Contextual Sensitivity Skills (CSS) of the Self-Regulated Learning Inventory showed a significant correlation ($R=.432$, $p<.05$) with correctness of the conclhat a person with high CSS seems to have good comprehensional ability to solve problems when reading the context. These findings are summarized in table A.

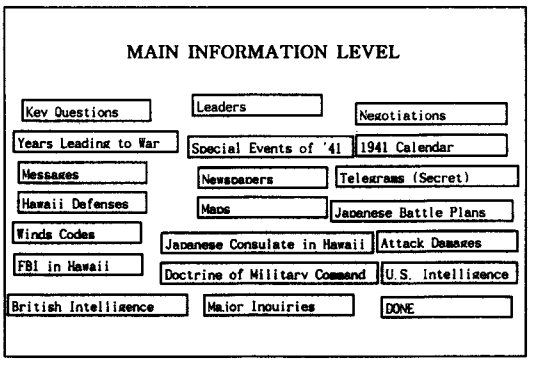
As shown in the 〈Table 1〉, GEFT and reading speed were positively correlated ($r=.392$, $p<.10$). It may be that FI student tend to read faster than FD students.

An interesting finding showed a significant negative correlation ($r=-.416$, $p<-.5$) between the use of guidance in the system and GEFT results. The Field Independent (FI) people did not seek the guidance (which was using MISSION menu bar or Key Questions button in the Pearl Harbor stack) as much as the Field Dependent (FD) people. This seems to support with the theory that the FI people tend to have well-developed knowledge structure, therefore, they did not seem to need to check and get assistance as often as FD individuals to monitor their knowledge structure. They seem to indicate that they had some knowledge structure to know where they were in the hypermedia system and what was relevant information for problem solving.

There were a few interesting findings that may call for further research. The correlation between high conclusion scores with Motivational Skills(MOS) ($r=0.308$) and between high conclusion scores with total scores of Self-Regulated, call Meta, ($r=0.335$) suggest some possibility of linearity. The result between CSS and the total time spent on most relevant information card (*** cards) indicated linear relation ($r=-0.332$). As Lindner & Harris suggested in 1993 the contextual sensitivity skills may attributing factor for subject to locate relevant information more than other styles [10], these two have correlation thus I think this is

〈Table 1〉 Summary of correlational analysis between different learning styles and their outcomes.

Dependent Variables	Cognitive Styles	Correlation Coefficient	P Value
Conclusion Scores	VTVP	r = .437	p < .05
	CSS	r = .432	p < .05
	MOSs	r = .369	p < .05
	Metacognition	r = .335	
	MCS	r = .308	
	LSS	r = .277	
	Total *** Cards	r = .295	
Total Time Spent on Stack	VTVP	r = .332	
	GEFT	r = −.416	p < .05
	CSS	r = .316	
Total *** Time	CSS	r = .332	
Cognitive Complexity	ECS	r = .278	
Reading Speed	GEFT	r = .392	p < .10



(Fig. 1) Main Information Level of the Pearl Harbor stack as shown in the computer screen

workth looking into closely.

6.2 Audit Trail Analysis (deriving the knowledge structure)

For this part of the analysis, I selected eight subjects to compare their audit trails and knowledge structure in detail. They were selected based on their extreme scores (High vs. Low) on their cognitive complexity and conclusion scores based on FD/FI from two groups as high and low metacognition identified as metacognition and nonmetacognition group. The Main Level Menu of the Pearl Harbor stack has 21 buttons as shown in (Fig 1). The Main Information Level of the stack had no hierarchical or chronological order of the placement of the buttons that linked for more information.

The audit trail showed the type of cards selected from the Main menu, the sequence and the level of depth indicating the relevance. As shown in (Fig 2) below, the participants navigational patterns generated four types: Top-Down, Left-Right, Inconsistent pattern, and No Pattern (student went through 5 cards only).

6.3 Field Independent and Field Dependent of None-Metacognition Group

The (Fig 2) shows summary of the audit trail results. The participants in the FI had some type of navigational patterns whereas the participants in FD did not have any systematic pattern. In a way all FI participants tend to cover all information cards in some structured or organized ways, and also received higher score in conclusion test results. Interestingly, these people mentioned in the exit questionnaire that they were concerned about missing critical information by skipping a button thus missing critical information. So, they said they tried to cover all buttons horizontally and/or vertically to insure they read all available information. This brought up an interesting issue. It seems that the freedom of topic choices didn't seem to have helped students solve the problem in HyperSpace. However, those who covered all of the buttons, seem to have performed better in conclusion scores. It also confirms the notion of interactivity or learner control may not be helpful for novice learners in this environment.

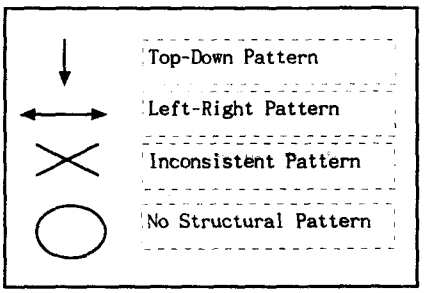
The examination of depth processing time is calculated by the number of most relevant information marks and the time spent on those cards. As shown in (Fig 2), FI Low spent only one-half of the time the FI high in reading the most relevant information cards. This may show that those who spent more time in cognitive efforts in relevant information do better in creating their own knowledge structure.

The FI High subjects seem to have low Self-Regulated scores overall. The general conception of self-regulated learner is that they regulate their own learning, thus they are capable of learning and transfer knowledge fast. I assumed that it would fit more with FI learning styles than FD, however, in this study, the scores of Self-Regulated learning skills were lower for those who had high FI. Furthermore, it seems like none of the four FD people in this study used any strategies or patterns in selecting their topics for relevant information since there were no consistent patterns.

6.4 Field Independent and Field Dependent of Metacognition Group

The audit trail of the Metacognitive group seems to show that the depth processing time gradually increased from FD-Low to FI-High. The time spent in developing their own knowledge structure seems to take time and taking time seems to help in problem solving. The FI High covered all but one button, and the rest did not cover some of the buttons.

One of interesting finding in this group was that FI High spent 6.93 minutes on META tools. The META tools, offered in the menubar, asked the participants to type-in their plans (strategy) and explain the reasons for their plans (why). FI-Low spent 12.70 minutes, FD-High spent 23.53 minutes, and FD-Low spent 24.34 minutes. This particular FD-Low seems to have been disoriented and distracted by the META menu bar for they spent long time using the tool but did not help them achieve high scores in the conclusion test. Although it was designed to help them, it seemed to have hindered some, especially the FD-Low group, in their learning.



(Fig. 2) Four different types of navigational patterns.

Overall those scored high in VTVP score seems to have scored higher in the conclusion test than those in the Low VTVP scored group. This support the general theory of those with the higher VTVP scores tending to perform better in a HyperSpace system because they might have the abilities to create their own mental model or knowledge structure to guide their own learning. The participants with the FD styles seems to require more guidance than those in FI styles for their learning, and any strategies used to cover all or more relevant information in hyperspace achieved higher test results.

7. Contribution to the Theory

The results of Audit Trail analysis indicated a possible linear correlation between Motivational Skills (MOS) of Self-Regulated skills and high scores in conclusion test. [15] reported that an individual with higher motivation had higher achievement on the average than those with lower motivation. This study showed that those who selected buttons in some consistent pattern or those who covered more information did better in their scores for conclusion and cognitive complexity level. This observation supported [15] studies that subjects who selected information

using some type of order gained more new knowledge.

The findings of correlation between VTVP and their tendency to seek guidance or help agreed with the findings of [3] that persons with stronger visualization skills may be more efficient at finding information in hypermedia learning environment. As [3] also reported people with good visualization ability are much more efficient at finding information than those with poor visualization ability. Furthermore, this study supported that people with better visualizaing skills may be better at constructing mental models or knowledge structure of the information architecture and using those models to direct their navigation for learning [3]. An experiment based on the interface of learners and the systems would be interesting. How would the results be different when the learners are familiar with the hyperspace system?

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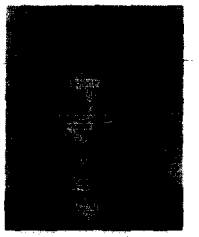

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